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For Calendar Year 1998

NEW ENGLAND TRANSPORTATION CONSORTIUM

NETCR11 January, 1999

This report was sponsored by the New England Transportation Consortium, a cooperative effort of the Departments of Transportation and the Land Grant Universities of the six New England States, and the US Department of Transportation's Federal Highway Administration.

NEW ENGLAND TRANSPORTATION CONSORTIUM

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A. INTRODUCTION

The New England Transportation Consortium is a cooperative effort of the transportation agencies of the six New England States. Through the Consortium, the states pool their professional, academic, and financial resources for transportation research leading to the development of improved methods for dealing with common problems associated with the administration, planning, design, construction, rehabilitation, reconstruction, operation and maintenance of the region's transportation system.

The Consortium operates through a) a committee structure consisting of: a Policy Committee, an Advisory Committee and Project Technical Committees, and b) a Coordinator and Lead State.

B. 1998 ACCOMPLISHMENTS

1. MAJOR TECHNOLOGY TRANSFER INITIATIVE UNDERTAKEN:

In 1998, the NETC launched a technology transfer initiative. The goals of the initiative were: a) to transfer useful findings from research funded by the Consortium to practitioners and b) to inform the transportation community of the Consortium's work

The Consortium presented six short courses on "Highway Applications of Tire Shreds," cooperated with the Penn State University Northeast Center for Excellence In Paving Technology in presenting a workshop for asphalt technicians from the New England states, and presented exhibits describing its work at one national and two state conferences.

In addition, the Consortium's researchers presented and/or published fourteen papers at technical conferences or for technical journals.

-Short Course on Highway Applications of Tire Shreds:

The short course presented the findings of two NETC funded research projects at the University of Maine at Orono on the use of tire shreds as a road construction material. One hundred and seventy-one transportation professionals from state and local agencies and the private sector attended six presentations of the short course throughout New England.

-Asphalt Binder Technician Workshop:

Researchers, at the University of Connecticut, for NETC project 96-1 presented a workshop on asphalt binders to sixteen asphalt technicians from throughout New England at the Connecticut Advanced Pavement Laboratory at the University of Connecticut.

-NETC Exhibits at Conferences:

NETC exhibits were presented at the following conferences: MA Highways' Research Showcase, Boston, MA, April 29, 1998; AASHTO Annual Meeting and Technology Transfer Fair, Boston, MA, November 7-9, 1998; Maine Transportation Conference, Augusta, ME, December 10, 1998.

2. **NETC RESEARCHERS ASSIST MAINE DOT WITH I-95 ANDROSCOGGIN RIVER BRIDGE PROJECT:**

Using new testing criteria developed from the NETC funded research project at the U.S. Army Cold Regions Research Engineering Laboratory on sheet membrane waterproofing (project 94-3), researchers assisted the Maine DOT in determining that a newly installed waterproofing membrane on the I-95 bridge over the Androscoggin river had not adhered properly to the bridge deck and needed to be reinstalled. A new membrane was installed, thereby avoiding future premature deterioration problems on the bridge.

3. **NEW RADAR ANTENNA DEVELOPED BY NETC RESEARCH FOR DETECTING DEFECTS IN REINFORCED CONCRETE BRIDGES SHOWS PROMISE:**

A novel high frequency wide ban radar antenna, developed for the NETC funded research project 94-2 at the University of Vermont and designed for detecting defects in reinforced concrete bridges, has been tested and determined to be capable of detecting delaminations of 1-3 meters in width.

4. **NETC RESEARCH PROJECT DEVELOPS GENERIC CLASSIFICATION FOR CONCRETE REPAIR SYSTEMS:**

Based on a nationwide survey and a review of manufacturers' product guides, a generic classification system has been developed by NETC researchers at the University of Rhode Island (Project 94-4) for concrete crack repair systems. The classification identifies crack repair systems as: a) epoxy based repair materials, b) modified cementitious repair materials, and c) cementitious repair materials.

5. **BRIDGE RAIL CRASH TESTING AND TIRE CHIPS RESEARCH COMPLETED:**

Copies of the following reports, which were completed in 1998 and present the findings of the above research, were provided to: New England's state transportation agencies and universities, the Federal Highway Administration, and the Region 1 AASHTO Research Advisory Committee:

-"Tire Chips as Lightweight Backfill for Retaining Walls-Phase II," Tweedie, J.J., Humphrey, D.N. and Sandford, T.C., University of Maine, Orono, March 11, 1998, NETCR 8.

-"Crash Testing and Evaluation of the NETC 2-Bar Curb Mounted Bridge Rail," Mak, K.K. and Menges, W.L., Texas Transportation Institute, February 1998, NETCR 10.

> *"Thank you for sending me a copy of the NETC Bridge Rail Crash Testing Report. It contains valuable information to the Philadelphia Bridge Section in our effort to include innovative Bridge Railing designs in our future projects."*
> Ahcene Larbi, Ph.D., Project Engineer
> City of Philadelphia, Streets Dept., Bridge Section

6. FUNDS PROGRAMMED FOR RESEARCH PROJECTS TO ADDRESS FIVE HIGH PRIORITY PROBLEM AREAS:

Five-hundred and forty thousand dollars was programmed for research on the following high priority problems facing the region's highway system:

-Asphaltic Expansion Joints:

New England's transportation agencies have, for many years, experienced durability problems with bridge expansion joints. In response to these problems, the use of asphaltic expansion joints was introduced in the early 1990's.

Since many of these installations are now at the end of their projected service life, there is a need to conduct a comprehensive evaluation of their performance over the past ten years and develop uniform guidelines for their future use.

-Bridge Scour Monitoring Systems:

The Federal Highway Administration has directed all state transportation agencies to analyze all of their bridges over water for potential failure due to stream scour. Current methods for identifying scour critical bridges, which are based on laboratory developed equations, are believed to be too conservative, resulting in an excessive number of bridges being classified as scour critical/susceptible.

There is a need to examine the feasibility of establishing a statewide network of scour monitoring devices to assist in the allocation of resources during potentially destructive flood events and to develop guidelines for the New England state transportation agencies to use in prioritizing scour related bridge improvements.

-Roadside Rest Areas:

Roadside rest areas like other segments of New England's transportation system are aging. Yet, in spite of increasing public demand for better transportation services and the importance of tourism to the New England economy, efforts to fund the repair and rehabilitation of these facilities are constrained by funding limitations.

There is a need to develop a methodology for accurately predicting rest area usage and the services that should be offered at these facilities which can be incorporated into a long term capital planning program for establishing priorities for the repair and rehabilitation of roadside rest areas.

-Concrete Removal Operations:

The logistics of many bridge rehabilitation projects involve planning for minimal disruption of traffic. This typically necessitates the use of stage construction where various components and/or portions of the bridge must be partially removed without causing damage to the component or portion that is to remain. As contractors search for ways to lower their operating costs, the use of larger hoe rams are common. It is uncertain what effects the use of such impact equipment has on adjacent concrete.

There is a need to identify the detrimental effects various concrete removal 'impact' techniques have on adjacent concrete and develop guidelines regarding the amount of energy that can safely be applied without compromising the integrity of the concrete that is to remain.

-Bridge Rail Transitions:

The Federal Highway Administration will require that all roadside barriers, including bridge rails and transition rails, installed on National Highway System bridge projects meet as a minimum the TL-3 criteria contained in National Cooperative Highway Research Program Report 350.

Since the New England Transportation Consortium has developed and successfully crash tested two bridge rail systems which meet the criteria contained in NCHRP Report 350, there is now a need to develop and crash test two bridge rail transitions for these bridge rail systems.

7. NETC SPONSORED RESEARCH RESULTS IN REPORTS, PAPERS AND PRESENTATIONS DURING 1998:

The following reports and presentations, arising from NETC sponsored research, were produced during 1998:

-Tire Chips As Lightweight Backfill for Retaining Walls, Phase II:

1) "Tire Shreds as Lightweight Retaining Wall Backfill, Active Conditions," Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 124, No. 11, Nov., pp. 1061-1070, 1998.

2) "Full Scale Field Trials of Tire Chips as Lightweight Retaining Wall Backfill, At-Rest Conditions," Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., *Transportation Research Record No. 1619*, Transportation Research Board, Washington, D.C., pp. 64-71, 1998.
3) "Highway Applications of Tire Shreds," Humphrey, D., a short course presented to transportation professionals in each of the six New England states sponsored by the NETC.

-Bridge Rail Crash Test Phase II: Sidewalk-Mounted Rail:

1) "Crash Testing and Evaluation of the NETC 2-Bar Curb Mounted Bridge Rail," Mak, K.K., and Menges, W.L., Texas Transportation Institute, February 1998, NETCR 10.

-94-1 Structural Analysis of New England Subbase Materials and Structures:

1) "Structural Analysis of New England Subbase Materials and Structures," Davis, J.S., Huston, M.I. and Lee, K.W. A paper presented at the 1998 Annual Transportation Research Board Meeting.
2) "Structural Properties of New England Subbase Materials of Flexible Pavements." A paper presented at the 5th International Conference on the Bearing Capacity of Roads, and Airfields on July 8, 1998.
3) Results of resilient modulus test in accordance with the AASHTO TP-46 procedure were presented at the 11th Rhode Island Transportation and Civil Engineering Forum on 10/21/98.

-94-2 Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques:

1) "GIMA Ground Penetrating Radar System For Infrastructure Health Monitoring," Huston, D.R., Hu, J.Q., Maser, K., Weedon, W., and Adam, C. Submitted to Journal of Applied Physics, October 1998.
2) "Ground Penetrating Radar for Concrete Bridge Health Monitoring Application," Huston, D.R., Hu, J.Q., Maser, K., Weedon, W., and Adam, C. Submitted for presentation at the SPIE Conf. on Nondestructive Evaluation of Aging Infrastructure and Manufacturing, Newport Beach, CA, March 1999.
3) "GIMA Antenna Design for Ground Penetrating Radar in Concrete NDE Application," Hu, J.Q., Huston, D., and Fuhr, P. Submitted for presentation at the SPIE Conf. on Nondestructive Evaluation of Aging Infrastructure and Manufacturing, Newport Beach, CA, March 1999.

4) "Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Maser, K., Hu, J.Q., Weedon, W., and Adam, C. Proc. GPR '98 7th International Conference on Ground-Penetrating Radar, The University of Kansas, Lawrence, KS, May 27-30, 1998.

-95-1 Use of Tire Chips/Soil Mixtures to Limit Frost Heave and Pavement Damage of Paved Roads

1) An abstract based on the field work for the project was submitted for possible presentation at the 10th International Conference on Cold Regions Engineering to be held in August 1999.
2) Dr. Humphrey presented 7 hour short courses on "Highway Applications of Tire Shreds" to each of the six New England states. Presentations sponsored by NETC.

-95-3 Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes:

1) A PowerPoint presentation of the interim findings was given at the Rhode Island Transportation and Civil Engineering Forum held on October 21, 1998 at the Chester H. Kirk Center for Advanced Technology, hosted by the University of Rhode Island.

C. PROGRESS OF ACTIVE PROJECTS

PROJECT NUMBER: None

PROJECT TITLE:
Tire Chips as Lightweight Backfill for Retaining Walls, Phase II: Full Scale Testing

PRINCIPAL INVESTIGATOR(S):
Dana N. Humphrey and Thomas C. Sandford, University of Maine, Orono

STATUS: Completed

INITIAL AGREEMENT DATE: 4/15/93

END DATE: N/A

PROJECT OBJECTIVES:
The objective of this project is to conduct full-scale tests using tire chips as backfill behind a 15-ft. high instrumented retaining wall. This will be supplemented with numerical analyses of the full-scale test results. This builds on Phase I of this project which determined the engineering properties of tire chips and indicated that tire chip backfill has the potential to produce low horizontal stresses on retaining walls. Based on the results from both phases, design guidelines for use of tire chips as retaining wall backfill will be prepared. It is expected that use of tire chip backfill will lower the cost of retaining wall construction and will put some of this nation's 2 billion waste tires to a beneficial use.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Testing Facility. The full scale testing facility is the second largest of its kind in the world. The facility is 15 ft. by 15 ft. in plan with 16 ft. high reinforced concrete side walls. The front wall has a reinforced concrete face supported by a structural steel frame. The front wall can be rotated about its base to achieve active earth pressure conditions. It is instrumented with load cells and pressure cells to measure the pressure of the backfill on the front wall. The back wall is timber lagging supported by a structural steel frame. The back wall is removed to unload the facility. A surcharge of 750 psf can be applied to the backfill using 216 concrete blocks with a weight of 700 lb. each. A gantry crane with a 3 ton capacity was constructed on top of the facility. It is used to lift backfill into the facility and to place the concrete surcharge blocks.

Construction of the facility was performed by the graduate student on the project, Jeff Tweedie, and the principal investigator, Dana Humphrey, with the help of several undergraduates. Construction began on June 4, 1993. The upper 3 to 7 feet of soil at the site was fill composed of a random mixture of soil, rocks, tree stumps, and cinders. It was removed and replaced with a compacted granular soil. Forms for the concrete foundation slab were constructed and the reinforcing was placed. The concrete for the foundation slab was placed on June 17, 1993. The next step was to place the reinforcing for the two concrete side walls, followed by erection of the wall forms. The concrete for the side walls was placed on July 9, 1993. The reinforced concrete face was placed on the supporting structural steel frames on August 18, 1993. The 3-ton gantry crane was erected on August 26 and 27, 1993. The concrete surcharge blocks were cast 21 at a time from August, 1993 through October, 1993. The front panels were placed and the instrumentation was installed during the Winter of 1993-4 and Spring, 1994. Construction of the facility was completed on June 30, 1994. In total, approximately 115 cy of concrete, 8 tons of reinforcing steel, and 15 tons of structural steel were used to construct the facility. Much of the structural steel was donated by the Cianbro Corp., Pittsfield, Maine and Owen J. Folsom Construction, Old Town, Maine. Their assistance was greatly appreciated.

Testing Program. Tests were conducted on gravel and tire chips from three producers. For each trial the backfill was compacted in 8-in. lifts with a vibrating plate compactor for the gravel and with a vibrating walk-behind roller for the tire chips After the backfill was placed, the surcharge blocks were applied. During backfill and surcharge placement, measurements were taken of the pressure exerted by the backfill on the wall. Settlement of the backfill caused by placement of the surcharge was also measured. The trial with gravel was conducted in July and August, 1994. Trials with two types of tire chips were conducted in the Fall of 1994. The trial with the third type of tire chips was conducted in the Summer and Fall of 1995. Testing was completed on October 13, 1995.

Analysis of Results. The pressure at the base of the wall with the full 750 psf surcharge, was less than half of the value expected for gravel backfill for all three types of tire chip backfill. This validates the basic premise of the research project; namely, that tire chips exert a much lower horizontal pressure than typical retaining wall backfills. Settlements measured for the trials with tire chips compared favorably to values expected based on laboratory compressibility tests conducted as part of an earlier NETC project. For a period of 2 months after placement of the surcharge, the tire chips underwent a small amount of time dependent settlement (2 to 3% of the fill thickness). Additional settlement after two months was negligible.

Final Report: The draft final report was submitted to NETC on August 5, 1997. Comments on the draft final report were received from the members of the NETC Technical Committee. The investigators meet with the Technical Committee on December 11, 1997 to discuss our responses to the comments. The Technical Committee was satisfied with our responses as indicated in a letter from Bruce A. Hosley dated December 16, 1997. The investigators made final editorial and formatting changes to the report. The required number of copies of the final report were transmitted to the NETC Coordinator in late March, 1998. This completed the work for this project.

REPORTS, PAPERS, AND PRESENTATIONS :

1. "Tire Chips as Lightweight Subgrade and Retaining Wall Backfill," by Humphrey, D.N. and Sandford, T.C. Symposium on Recovery and Effective Reuse of Discarded Materials and By-Products for Construction of Highway Facilities, FHWA, Denver, Colorado, October 19-22, 1993.

2. "Use of Tire Chips as Subgrade Insulation and as Lightweight Fill for Highway Construction," Humphrey, D. N. Presented at the 18th Annual Meeting of the Asphalt Recycling and Reclaiming Association, Pompano Beach, Florida, February 23-26, 1994.

3. "Use of Tire Chips in Highway Construction," Humphrey, D. N. A presentation to the New England Environmental Expo, Boston, Massachusetts, May 9, 1995.

4. "Use of Tire Chips in Highway Construction," Humphrey, D. N. A presentation to the AASHTO Region 1 RAC Meeting, Portland, Maine, May 23, 1995.

5. "Tire Chips for Highway Construction," Humphrey, D. N. Presented to the Northeast Recycling Council in Sturbridge, Massachusetts on December 8, 1995.

7. "Tire Chips: A New Road Building Geomaterial," Humphrey, D. N. Presented at the Conference on Waste and Recycled Materials in the Transportation Infrastructure, held in conjunction with the 75th Annual Meeting of the Transportation Research Board, January 7, 1996.

8. "Use of Tire Chips in Civil Engineering." Presented at the 76th Annual Meeting of the Rubber Association of Canada, March 7, 1996.

9. "Civil Engineering Uses for Tire Chips," Humphrey D. N. A six-hour short course presented to the Nebraska Department of Environmental Quality, the Maine Dept. of Transportation, the Texas Engineering Extension Service, the Manitoba Tire Stewardship Board, the Alberta Tire Recycling Management Board, and the Arkansas Department of Pollution Control and Ecology, 1996.

10. "Civil Engineering Uses for Scrap Tires," Humphrey, D. Presented at Scrap Tire '96 held in Chicago, Illinois on August 16, 1996.

11. "Tire Shreds as Retaining Wall Backfill, Active Conditions," Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 124, No. 11, Nov., pp. 1061-1070, 1998.

12. "Full Scale Field Trials of Tire Chips as Lightweight Retaining Wall Backfill, At-Rest Conditions," Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., *Transportation Research Board No. 1619*, Transportation Research Board, Washington, D.C., pp. 64-71, 1998.

13. Dr. Humphrey presented 7 hour short courses on "Highway Applications of Tire Shreds" to each of the six New England states. Presentations sponsored by NETC.

PROJECT NUMBER: None

PROJECT TITLE: Bridge Rail Crash Testing- Phase II: Sidewalk-Mounted Rail System

PRINCIPAL INVESTIGATOR(S):
Eric C. Lohrey, Connecticut Department of Transportation
Charles F. McDevitt, Federal Highway Administration
Joseph B. Mayer, Southwest Research Institute

STATUS: Completed

INITIAL AGREEMENT DATE: October 1, 1996

END DATE: December 30, 1998

PROJECT OBJECTIVE: To conduct three (3) full-scale crash tests on the NETC 4-Bar Sidewalk-Mounted Tubular Steel Bridge Railing in accordance with the recommended procedures in National Cooperative Highway Research Program (NCHRP) Report 350 for a Test Level 4 Longitudinal Barrier.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Initiated in 1988, Phase I of this project developed the NETC 2-Bar Curb-Mounted Bridge Rail, and successfully crash tested it in accordance with AASHTO Performance Level 2 (PL-2) and NCRP Report 350 Test Level 4 (TL-4). The Phase I crash testing was completed in December 1994 and the Draft Final Report was issued by the testing agency, Texas Transportation Institute (TTI) in June 1996. After being revised in accordance with review comments from FHWA and NETC, the Phase I Final Report was released for publication in February 1998, and distributed by NETC in November 1998.

Based on a recommendation from the Bridge Rail Crash Test Technical Committee, funds were allocated in February 1995 to develop and crash test a sidewalk-mounted version of the Phase I Bridge Rail. With the Technical Committee's approval of a 4-bar, sidewalk-mounted, prototype bridge rail design in September 1995, the NETC Lead Agency was directed by the Advisory Committee to proceed with the development of an agreement with FHWA for crash testing of the 4-bar, sidewalk-mounted prototype design. A scope of work for this Phase II crash testing was developed by FHWA in December 1995, and subsequently approved by the NETC Technical Committee assigned to monitor the project. A Letter of Agreement providing funds, and authorizing FHWA to enter into an agreement with Southwest Research Institute, San Antonio, Texas to conduct the crash tests was executed in October 1996.

The Phase II bridge rail test section was constructed during 1997, and all three (3) specified crash tests were conducted in November and December 1997. Although preliminary results from these crash tests indicate that the NETC 4-Bar Sidewalk-Mounted Bridge Rail passed all requirements of NCHRP Report 350 for a Test Level 4 Longitudinal Barrier, some of the required electronic data was not recorded during the tests. The loss of data was caused by malfunctioning accelerometers. In order to restore lost data to the satisfaction of FHWA and NETC, the testing agency was instructed to analyze high-speed films of the crash tests to estimate the specific occupant and vehicle acceleration values required in NCHRP Report 350. While the film analyses wre being conducted, the Phase II Draft Final Report was submitted to the NETC Technical Committee for review in November 1998. In addition, all crash test documentation was forwarded to the FHWA Office of Engineering for evaluation to determine if the original submission of test data is sufficient to grant approval of the NETC 4-Bar Bridge Rail for use on the National Highway System (NHS) in accordance with NCHRP Report 350.

REPORTS/PAPERS DEVELOPED, PRESENTATION MADE:

1. NETC 2-Bar Curb Curb-Mounted Bridge Rail - Design Plans and Specifications, Revised January 1997.

2. NETC 4-Bar Sidewalk-Mounted Bridge Rail - Design Plans and Specifications, Revised January 1997.

3. "Crash Testing and Evaluation of the NETC 2-Bar Curb-Mounted Bridge Rail," Mak, K.K., and Menges, W.L., February 1998, NETCR10.

PROJECT NUMBER: 94-1

PROJECT TITLE:
Structural Analysis of New England Subbase Materials and Structures

PRINCIPAL INVESTIGATOR(S):
K. Wayne Lee and Milton T. Huston, Jeffrey S. Davis, and Sekhar Vajihala, University of Rhode Island, Department of Civil Engineering

STATUS: Continuing

INITIAL AGREEMENT DATE: 9/1/95

END DATE: 3/31/99

PROJECT OBJECTIVES:
The objectives of this research are:
1. To compile a database of subbase aggregate properties by aggregate types common to New England.
2. To collect data from existing analyses of natural aggregates and recycled material/aggregates blends.
3. Develop recycled material blends.
4. Recommend appropriate testing for state agencies to develop optimum properties for specific sources and various combinations of blended materials projects.

The objectives were amended to modify the existing Instron testing system for the AASHTO TP46, and to characterize the subbase materials with and without reclaimed asphalt pavement (RAP).

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:

1. Although Instron Corp. and Law Engineering modified the testing equipment, some problems were encountered to perform a series of preliminary testing: load cell calibration and LVDTs. After the problem with load cell had been resolved by working with Instron engineers, the quality control testing was resumed with new LVDTs in accordance with the AASHTO TP-46 procedure of resilient modulus test.

2. The final experimental design was formulated to collect structural properties for the estimation of structural layer coefficients.

3. The resilient modulus test was started with MA Process Gravel in accordance with the AASHTO TP-46 procedure. However, the testing system required further tuning and calibration. Therefore, the system was modified with the help from Mr. Richard Boudreau of Law Engineering and Ken Salomon of Instron Corp. from 8/20/98 to 8/22/98.

4. The resilient modulus testing was resumed for all eight subbase materials starting with MA Process Gravel. All testing has been completed successfully.

5. The data analysis has been started. A framework has been formulated to illustrate the application of the data collected, e.g., the estimation of layer coefficients from M_R test results in accordance with the AASHTO TP-46 procedure.

6. The statistical analysis of the structural property data was performed, and the results were interpreted realistically.

7. After a series of testing with different amounts of RAP, optimum performance characteristics for aggregate type and recycled material blends have been developed.

8. The effectiveness of the developed parameter values through a design example for the typical pavement structures in New England using the 1993 AASHTO Guide and/or DARWin™ 2.01 has been demonstrated.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Structural Analysis of New England Subbase Materials and Structures," Davis, J.S., Huston, M.I., and Lee, K.W. Presented at the 1998 TRB Annual Meeting.

2. "Structural Properties of New England Subbase Materials of Flexible Pavements" presented at the 5th International Conference on the Bearing Capacity of Roads, and Airfields on July 8, 1998.

3. Results of resilient modulus test in accordance with the AASHTO TP-46 procedure were presented at the 11th Rhode Island Transportation and Civil Engineering Forum on 10/21/98.

PROJECT NUMBER: 94-2

PROJECT TITLE:
Nondestructive Testing of Reinforced Concrete Bridges Using Radar Imaging Techniques

PRINCIPAL INVESTIGATOR(S) :
Dryver R. Huston, University of Vermont

STATUS: Continuing

INITIAL AGREEMENT DATE: 10/16/95

END DATE: 5/31/99

PROJECT OBJECTIVES:
The overall goal of this project is to advance the state-of-the-art in ground-penetrating-radar (GPR) imaging techniques so that it will become an even more practical and precise tool for assessing the integrity of reinforced concrete bridge decks, with particular attention directed towards the specific problems of New England bridges. The plan is to conduct numerical, laboratory and field studies with the ultimate goal of developing a reliable and easy-to-use field technique. **Phase I** involves the numerical modeling of the interactions of defects in concrete bridge decks and GPR through the adaptation of available algorithms, software and dielectric parameter data. **Phase II** involves the laboratory verification of the numerical models through the testing of specimens with known defects. **Phase III** involves the development of radar waveform image processing techniques so that defect conditions can be identified readily. **Phase IV** involves the field testing of the methods on selected bridge structures in New England. **Phase V** involves the development of the appropriate documentation so the technology developed in this project is capable of being used by the state transportation agencies. This is an interdisciplinary project that has a team of investigators from Vermont and Massachusetts: Prof. Dryver R. Huston and Prof. Peter L. Fuhr from the University of Vermont; Dr. Kenneth Maser of Infrasense, Inc; and Dr. William Weedon of Applied Radar Analysis, Inc. The project will take three years to complete.

Overview: Due to delays in instrument acquisition and assembly, a no-cost extension of the end date of the project has been requested and granted. The revised end date is May 31, 1999. The progress on the project has been a little slower than anticipated, but it is still expected to be completed by the revised end date. A radar system for field tests has been assembled and has undergone preliminary field-testing. This system contains a step-frequency radar system, with a high-frequency bandwidth of 0.5 to 6.0 GHz. Laboratory slabs of concrete with controlled defects have been fabricated and tested in the laboratory. A critical review of the existing radar data processing algorithms has been undertaken. A software system has been developed for the rapid assessment of field data. A more sophisticated off-line data processing system is currently under development. The ability of this system to reliably detect defects in bridge decks under field conditions remains unproven. Additional field tests are anticipated.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:

Phase 1 - Numerical Modeling: The primary goal of this task is to develop numerical models of the interaction of GPR with concrete pavements so that field conditions can be simulated and investigated. This task was largely completed in the previous year's work. This task is 95% complete.

Phase 2 - Design and Conduct of Laboratory Evaluations: The goal of the laboratory studies is to fabricate concrete slabs with various defects and features that can be identified with a radar system. A series of concrete slabs, with embedded defects, including delamination produced by accelerated corrosion, have been fabricated. A novel, high frequency wide band radar antenna has been designed for this testing. A series of tests were undertaken with both the system developed at UVM and with one that has a bandwidth of up to 20 GHz from Sandia National Labs. These tests indicated that the new antenna was capable of detecting artificial air-filled delamination with a width of 1-3 m. Additional laboratory testing has been undertaken with the field system. This task is 75% complete.

Phase 3 - Development of Radar Data Processing Software: Radar signals can be somewhat complex because they contain a mixture of radar pulses that are reflected off of several objects and material layers. In order to comprehend what a series of radar signals has to do with the condition of the deck or roadway, it is necessary to use computer enhancement and data processing techniques on the raw radar data. A critical survey of existing techniques has been undertaken. These techniques range from simply correlating the magnitude of the top layer reflectivity with damage to data visualization techniques to 3-D feature recognition systems. Limited versions of the simpler and more promising techniques have been formulated and evaluated. This task is 40% complete.

Phase 4 - Correlation of Software with Laboratory and Field Data: Three field tests with the radar system were completed. The purpose of the tests was primarily for the development and debugging of the radar system. The results of the tests are preliminary, but the system is able to detect features, such as filled potholes and other visible damage. It should be noted that the bridge that was the subject of the tests was quite damaged and maybe was not an ideal candidate for the tests. This task is 35% complete.

Phase 5 - Implementation of Research Results: The documentation of Phases 1-3 has been partially completed. This task is 25% complete.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "GIMA Ground Penetrating Radar System for Infrastructure Health Monitoring," Huston D.R., Hu, J.Q., Maser, K., Weedon, W., and Adam, C. submitted to Journal of Applied Geophysics, October 1998.

2. "Ground Penetrating Radar for Concrete Bridge Health Monitoring Application," Huston, D., Hu, J.Q., Fuhr, P., Maser, K., Weedon, W., and Adam, C. submitted for presentation at the SPIE Conference on Nondestructive Evaluation of Aging Infrastructure and Manufacturing, Newport Beach, CA March 1999.

3. "GIMA Antenna Design for Ground Penetrating Radar in Concrete NDE Application," Hu, J.Q., Huston, D., and Fuhr, P. submitted for presentation at the SPIE Conference on Nondestructive Evaluation of Aging Infrastructure and Manufacturing, Newport Beach, CA, March 1999.

4. "Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Maser, K., Hu, J.Q., Weedon, W., and Adam, C., Proceedings GPR '98 7th International Conference on Ground-Penetrating Radar, The University of Kansas, Lawrence, KS, May 27-30, 1998.

PROJECT NUMBER: 94-3

PROJECT TITLE: Procedures for the Evaluation of Sheet Membrane Waterproofing

PRINCIPAL INVESTIGATOR (S): Charles J. Korhonen, Jim Buska, and Edel Cortez, U.S. Army Cold Regions Research and Engineering Laboratory (CRREL).

STATUS: New

INITIAL AGREEMENT DATE: 12/31/97

END DATE: 3/24/99

PROJECT OBJECTIVE: Waterproofing membranes have been used by transportation agencies in New England for more than two decades to prevent water and deicing salts from penetrating concrete bridge decks and corroding the embedded reinforcing steel. Although field performance studies have proven the efficacy of waterproofing membranes at extending bridge life, there are problem areas where improvements in test procedures or materials are needed. For example, if a membrane cannot be fully adhered to the deck, or somehow becomes damaged during construction, or is unable to resist splitting when cracks develop in the deck or bituminous overlay, moisture and chlorides can leak through the system and accelerate bridge deterioration. The objective of this project is to develop new or modify existing laboratory tests for evaluating sheet membrane waterproofing for their ability to resist cracking, blistering and puncturing.

This project consists of four tasks. Task 1 will develop a test to evaluate adhesion between the membrane and a concrete substrate. Membranes that exhibit good bond should be better able to resist the development of blisters caused by the vaporization of moisture or other gases at the concrete surface and to remain intact during the life of the bridge. Task 2 will analyze the tensile strength and elongation of a membrane as a function of temperature because membranes are most likely to split at low temperature, when cracks widen in concrete. Task 3 will develop a test to measure the resistance of a membrane to rock puncture as membranes are most susceptible to this type of puncture during construction. Task 4 will examine the water vapor permeability of a membrane with the idea that more breathable membranes should be better able to resist blistering.

It was acknowledged at the outset of this project that the findings from these four tasks, by themselves, might not necessarily provide sufficient insight into how well a given membrane may perform on a bridge. However, these results can be used to rank one membrane against another and, if combined with field performance studies, should lead to a much better understanding of membrane performance.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Prior to initiating the laboratory study in March 1998, several bridge-membrane projects were inspected during the summer of 1997 by the principal investigators to aid in the understanding of how membranes are installed. Briefly, the findings showed that great skill and care is required to correctly install a membrane and that, if any error is made, blisters are quick to form. These inspections set the stage for the laboratory studies that followed.

The adhesion study, task 1, consisted of adhering membranes to carefully prepared concrete surfaces, cutting the membranes into strips and peeling the strips off the concrete at a constant rate of extension at room temperature. Two sets of test specimens for each of six membrane types selected for testing were fabricated: three specimens were made by CRREL and the supplier of each membrane made three. In all, 180 strips were tested for adhesion by September 1998. Though the results have not been fully analyzed, they show that a single number does not easily characterize adhesion. For example, some membranes display a low but uniform adhesion compared to others that vary from very high to essentially zero adhesion at points along the peel distance, which helps to indicate which membranes might be likely to develop areas of weak adhesion when applied under less-forgiving field conditions.

It is areas of weak adhesion that lead to blisters, and ultimately to failed pavements. The field study that preceded this project demonstrated that blisters do not occur on their own but, rather, are caused by the expansion of air pockets inadvertently trapped between the membrance and the deck during construction. Mathematically, it can be shown that a membrane does not have to be perfectly applied to a deck- -voids, the size of a quarter, are acceptable.

Thanks to this conclusion about minimum void size, guidance was provided to the Maine DOT in August 1998 on a membrane that was being applied to the I-95 bridge over the Androscoggin river. Pull tests showed that the membrane, though adhered to the deck, was only adhered in spots. Areas much large than quarters were found to be completely unbonded, which led to the decision to remove the membrane and to start over. The new membrane was reported to have bonded much better and, as a result, should perform much better than if the first membrane was left in place.

The adhesion study, task 2 measured the tensile strength and elongation of each of six membranes at various temperatures. The tensile strength indicates how well a membrane can resist movement while an elongation measurement determines how well movement can be accommodated. The test consists of pulling apart dogbone shaped specimens at a constant separation rate. Three specimens were tested of each membrane type at five temperatures ranging from room temperature to -4 degrees F. The testing, completed in November 1998, showed that most membranes become a bit stronger at low temperature, but that some dramatically reduce in their ability to stretch. Though the data has not been fully analyzed, it is clear that some membranes are more prone to splitting during cold weather than are others. Findings such as this should aid in the decision of which membranes to use in bridges subjected to cold weather.

The puncture resistance study, task 3, consists of devising an apparatus and puncture tip geometry that results in test values that are all in the same scale for the subject membranes. Various test methodologies are currently in use. Different membrane manufactures use different methods. A part of our work consisted in examining the existing methods. Then we assessed various combinations of load apparatuses and penetrating tip geometry. After various pre-tests and adjustments, tip geometry and suitable test apparatus were defined. Numerous tests were conduced in October 1998 on samples of each of the six sheet membranes under evaluation. The test data is being processed and it will be included in the final project report. We also plan to include a detailed description of the test appartus and of the effective tip geometry. The test results show significant differences in the resistance to puncture among membranes from different manufacturers. This should prove useful in selecting membranes for bridge decks.

The water vapor permeability (WVP) study, task 4, will proof-test one sample of each membrane using two modified test cup procedures (normal and inverted). The testing protocol is a modified version of ASTM E96 "Water Vapor Transmission of Materials" which is under consideration for inclusion in this ASTM test procedure. An apparatus for the test was designed and construction initiated. Membrane testing will start as soon as the appartuses are ready.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 94-4

PROJECT TITLE: Durability of Concrete Crack Repair Systems

PRINCIPAL INVESTIGATOR (S): George Tsiatas, University of Rhode Island

STATUS: New

INITIAL AGREEMENT DATE: 9/1/97

END DATE: 2/28/99

PROJECT OBJECTIVE: The objective of this research project is to determine the durability of structural concrete crack repair systems under fatigue loading freeze-thaw conditions. This will be accomplished by performing variable temperature fatigue testing and freeze-thaw testing on concrete beams that have been repaired with various crack repair systems. These systems will be selected from a generic classification of systems in order to determine the durability of generic types of repair systems rather than that of specific repair products. The testing program will follow modified procedures of ASTM C78 and ASTM C666 for the fatigue and freeze-thaw specimens, respectively.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Literature Search. A literature search of all the research recently or currently performed with respect to durability and crack repair systems has been conducted. The most relevant articles have been organized and abstracted. These abstracts include publication information as well as a summary of the content with respect to this research project.

Methods. A generic classification of concrete repair systems has been developed. This classification is a result of the literature search, a nationwide survey, review of manufacturers' product guides, and meetings with RIDOT personnel. The classification separates crack repair systems into 3 categories: a) Epoxy Based repair materials, b) Modified Cementitious repair materials, and c) Cementitious repair materials.

In developing this classification, a survey has been sent to the state Departments of Transportation throughout the United States. In addition, the six New England states were solicited twice, including a request for the concrete crack repair approved materials lists. In response, 19 states have either replied or completed the survey, and 4 New England states have supplied the approved materials list.

Specimen Preparation: The specimens for the fatigue testing measure 6" x 6" x 20." The specimens for the freeze-thaw testing measure 3" x 4" x 16". The mix design for all beams is RIDOT Class X 3/4" AE concrete. Excluding the control units, all beams are cast with metal inserts placed in the middle third. These inserts vary in thickness to form cracks in the beams of widths 0.02", 0.25", and 0.50." The crack depths extend from the tensile face to the neutral axis of the beams. The crack lengths are the width of the beams, 6" for the fatigue specimens and 4" for the freeze-thaw specimens.

The beams are cast in batches of 30 fatigue and 17 freeze-thaw specimens each. To date, three batches have been cast. The casting dates for these batches are 8/21/98. 9/16/98, and 10/2/98. These castings have produced 90 fatigue specimens and 43 freeze-thaw specimens. For a more in-depth description of the casting procedure as well as the curing process, please refer to NETC 94-4, Summary Report One.

Repair Systems. After the concrete beam specimens have cured, appropriate crack repair systems will be applied to the cast in place cracks. These cracks will be cleaned by means of a high-pressure water jet and compressed air. In addition the cracks will receive additional preparation as specified by the manufacturers' guidelines. After the beams are repaired, they will again be allowed to cure, and then tested.

Currently, repair systems have been collected from three manufacturers and two more are expected to deliver soon. The three manufacturers are Fosroc, Silpro, and Sto. It is expected that Mater Builders and Sika will respond soon.

Repair systems will be selected from these or other companies as representative products of the generic classification previously described.

Testing Program. The testing for the fatigue specimens follows a modified ASTM C78 'Standard Test Method)' procedure. The repaired beams are loaded at third points and are simply supported. The loading will be a harmonic with frequency, intensity, and duration to be determined based on several trial tests. At this point, trial testing is expected to be performed with frequencies near 1 cycle per second, intensities near 50 percent the modulus of rupture, and durations near 10,000 cycles.

Testing will be duplicated over a range of temperatures. These temperatures are 25° F, 62.5° F, and 100° F.

The testing for the freeze-thaw specimens follows a modified ASTM C666 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing' procedure. The modification to this procedure is primarily in the specimen curing. In order to repair the beams according to manufacturers's specifications, the specimens will be removed from their water curing after 14 days and allowed to dry. After the repair systems have been applied and have had adequate time to cure, they will be placed in the water bath for seven days and allowed to saturate immediately prior to freeze-thaw testing.

The testing program utilizes a factorial experimental design to determine the total number of required specimens and for statistical analysis. This design is modified to account for the incompatibility of certain repair systems with certain crack widths. It also is adjusted to reduce the number of control units required. A standard design would require control specimens for each repair system when in fact one set of control units for each crack width and temperature is sufficient for comparisons to be made with all the repair systems.

Equipment. There have been several setbacks due to equipment difficulties. These problems include the third point bending apparatus, the environmental chamber, and the laboratory utilities.

The third point bending apparatus had been damaged from previous misuse. Presently, the damaged parts have been replaced and the connections have been maintained for attachment to a 110 kip computer controlled MTS Loading Unit. Testing on supplemental beams will be performed soon to establish the loading properties that will be utilized for the repaired beams.

The environmental chamber required modification to perform adequately for this research project. These problems are also currently being resolved.

Finally, the utilities to the laboratory have had several problems. Building modification has led to inadvertent loss of cooling water for the pumps, electricity for the MTS computer and controller, and compressed air.

Website: In an effort to share the information collected through this research, a website has been established. It contains information regarding the objectives, specimen preparation, and testing procedures. As results become available, these will also be posted. The site is located at http://mykonos.eve.uri.edu/research/netc/NETC.html.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Durability of Concrete Crack Repair Projects," Robinson, J. Presented at the University of Rhode Island Graduate Seminar Series, Kingston, RI, November 19, 1997.

PROJECT NUMBER: 95-1

PROJECT TITLE:
Use of Tire Chips/Soil Mixtures to Limit Frost Heave and Pavement Damage of Paved Roads

PRINCIPAL INVESTIGATOR(S):
Dana N. Humphrey, University of Maine, Orono, Maine

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 12/31/97

PROJECT OBJECTIVE:
The objective of this research is to determine the tire chip/soil mixture ratio, tire chip/soil mixture layer thickness, and thickness of overlying soil cover (distance from top of tire chips/soil mixture layer to bottom of pavement) that will optimize the thermal resistivity and permeability without resulting in excessive deflections in the flexible bituminous pavement layer. This will be accomplished through laboratory measurement of the thermal conductivity and permeability of tire chips and tire chips/soil mixtures. The results of the laboratory tests will be used to design and construct a prototype pavement structure underlain by tire chips and/or tire chip/soil mixtures.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Laboratory Measurement of Thermal Conductivity. A large scale one-sided mode insulated-hot-plate apparatus was constructed to measure the thermal conductivity of tire chips. The apparatus measures 3 ft. by 3 ft. in plan and can accommodate a 1-ft. thick sample. The sides of the apparatus are insulated with 1 ft. of extruded polystyrene insulation to minimize lateral heat loss. The primary heater, located in the center of the apparatus, supplies a measured amount of energy to the overlying sample. The temperature of a second heater, called a backflow plate, located at the bottom of the apparatus is adjusted to prevent heat loss from the bottom of the apparatus. The temperature gradient through the sample is measured with thermocouples. The gradient along with the energy input to the primary heater provides the information needed to calculate the thermal conductivity. The samples were compacted into the apparatus using 60% of standard Proctor energy. The tests were conducted with three surcharge levels to simulate compression of the tire chips under an overlying soil layer: no surcharge, 187 psf, and 375 psf.

Tests on air dried samples were conducted on gravel, five types of tire chips and six different tire chip/gravel mixtures. It was found that the apparent thermal conductivity[1] of air dried tire chips varies from about 0.11 to 0.18 Btu/hr/ft/°F and that of air dried gravel varies from 0.30 to 0.35 Btu/hr/ft/°F. Tire chips with steel belts had a higher thermal conductivity than chips with glass belts. The apparent thermal conductivity of air dried tire chip/gravel mixtures was 0.23 to 0.34 Btu/hr/ft/°F for 33% tire chips/67% gravel and 0.17 to 0.29 Btu/hr/°F for 67% tire chips/33% gravel.

The effect of temperature gradient on thermal conductivity was investigated. It was found that the thermal conductivity of tire chips increases as the gradient increases. This is most likely due to increased heat transfer due to air circulation within the voids as the temperature gradient increases.

The Laboratory measurement of the thermal conductivity of moist samples showed that moist gravel has a measured thermal conductivity that is more than two times that of dry gravel. For example, the thermal conductivity of moist gravel at half surcharge was 1.63 W/m°C compared to 0.563 W/m°C for dry gravel at half surcharge. A similar difference was measured for dry and moist samples with 33% Palmer tire chips/67% gravel. In contrast, the thermal conductivities of Palmer tire chips is about the same for dry and moist samples. This is also true for 67% Palmer tire chips/33% gravel. This shows that the thermal conductivity of samples composed primarily of tire chips is not dependent on the moisture condition.

The thermal conductivity of steel belted Pine State tire chips was backcalculated from subsurface temperature measurements made at the Richmond, Maine, field trial. This was possible because the temperature profile had reached a steady state condition by mid-February, 1994. The temperature profile on February 14, 1994 was used to backcalculate a thermal conductivity of 0.20 W/m°C (0.12 Btu/hr/ft/°F) As a check, the modified Berggren equation was used with this value to predict the depth of frost penetration for the winter of 1993-4. The predicted depths agreed very well with the measured depths (-5% to +11% difference). The laboratory measured thermal conductivity of Pine State tire chips at an overburden pressure corresponding to the field value was about 0.26 W/m°C (0.15 Btu/hr/ft/°F). One reason that this value is somewhat higher than the field value is that the temperature gradient used in the laboratory test was higher than the field gradient.

<u>Laboratory Measurement of Permeability</u>. Permeability tests on tire chips and tire chip/gravel mixtures were completed. In total, one test was performed on gravel, five on tire chips, and six on tire chip/gravel mixtures. Tests were conducted in a 12-in. diameter constant head permeameter constructed for a previous NETC project. The samples were tested at several compressions to simulate the effect of the overburden pressure. The permeability decreased as the void ratio of the sample decreased and as the size of the tire chip decreases. Yet even with smaller tire chips and lower void ratios, the permeability was higher than many gravels used for highway construction. However, the permeability of 67% tire chip/33% gravel mixtures was nearly reduced to the value obtained for 100% gravel. Thus,

to take advantage of the high permeability of the tire chips it is necessary to use 100% tire chips.

Field Trial. The full-scale field trial was constructed on the University of Maine campus in the Fall, 1996. The field trial design consisted of three sections underlain by 6 or 12 in. of tire chips and two sections underlain by 12 in. of tire chip/gravel mixtures. The tire chip and tire chip/gravel layers are covered by 19 in. of subbase aggregate except in one section where the tire chip layer is covered by 13 in. of subbase aggregate. Each section has a vertical string of 12 to 20 thermocouples to measure the temperatures above, in, and below the tire chip layer. In addition to the five tire chip sections there is a control section underlain by 25 in. of subbase aggregate. An edge drain with a depth of approximately 3 ft. 6 in. and a width of approximately 2 ft. 3 in. mix was located at one edge of the road. The test section was covered by 5 in. of hot bituminous pavement (3.5 in. of base and 1.5 in. of hot mix bituminous, Type C). The design was summarized in a draft *Field Test Protocol*. This was distributed to the technical advisory committee on July 19, 1996.

Construction of the test section began September 6, 1996. A contractor was hired to perform the excavation required for the test section itself. Next, the tire chip and tire chip/soil mixtures were placed. The material was hauled from a stockpile located about a mile from the project by the investigators using a 3-ton capacity dump trailer pulled by a pickup truck. The tire chips were spread by hand and compacted by a 10-ton vibratory roller. Gravel subbase aggregate was delivered to the site by Owen J. Folsom Construction. The aggregate meets the requirements of Maine DOT Type D subbase aggregate. It was spread with a small tractor and compacted with a 10-ton vibratory roller. Gravel placement was completed on September 30, 1996. The road was paved in late October.

Subsurface temperatures were monitored throughout the winter of 1996-7. Temperature measurements showed that a 12-inch thick layer of tire chips provided significant insulation allowing the frost to penetrate no more than a few inches into the subgrade soil. Somewhat more frost penetration occurred in a section with 6 in. of tire chips. However, in a section with a 12-inch thick mixture of 33% chips and 67% gravel had the same frost penetration as the control section. A section with a mixture of 67% chips and 33% gravel gave intermediate results. Significantly less frost heave was observed in the tire chip sections compared to the control section.

Pavement deflections were measured with a Benkelmann Beam and a Falling Weight Deflectometer in April and August, 1997. Pavement deflections increased as the thickness of soil cover over the tire chip layer decreased. Results from analytical methods compared favorably with measured field deflections. Undesirable tensile strains in the pavement can be controlled with a sufficient thickness of soil cover.

Final Report. The draft final report was submitted for review to the NETC technical committee in July, 1998. Comments were received back from the committee members. The principal investigator met with the committee members to discuss the comments. The report will be finalized and submitted to NETC early in 1999.

1The apparent thermal conductivity includes the effects of conduction through the sample and heat transferred by convection of air through the voids.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Laboratory and Field Measurement of the Thermal Conductivity of Tire Chips for Use as Subgrade Insulation," Humphrey, D., Chen, L. H. and Eaton, R. A. A paper submitted to the Transportation Research Board at the session on "Properties of Unconventional Aggregates" at the Annual Meeting of the Transportation Research Board, Washington, D.C., January 1997.

2. An abstract based on the field work for the project was submitted for possible presentation at the 10th International Conference on Cold Regions Engineering to be held in August, 1999.

3. Dr. Humphrey presented 7-hour hour short courses on "Highway Applications of Tire Shreds" to each of the six New England states. Presentations sponsored by NETC.

PROJECT NUMBER: 95-2

PROJECT TITLE:
Suitability of Non-Hydric Soils for Wetland Mitigation

PRINCIPAL INVESTIGATOR(S):
Larry K. Brannaka and Christine Evans, University of New Hampshire

STATUS: Completed

INITIAL AGREEMENT DATE: 9/1/95

END DATE: Completion of Work

PROJECT OBJECTIVES:
The objectives of this research are three-fold. Specifically they include the following:

1. Identify the characteristics and properties of non-hydric soils which have been successfully used in existing wetland mitigation projects.
2. Describe the site conditions that will influence the success of using non-hydric soils for wetland mitigation.
3. Develop recommendations for the selection of non-hydric soils or non-hydric soil amendments for mitigation purposes based on existing site conditions.

The final objective depends on successfully completing the preceding objectives.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
The literature review indicated that the hydrologic conditions govern the formation of the hydric soils. Of primary concern is whether the soils are periodically saturated, and the annual duration of saturation. Hydric conditions are formed when soils are poorly drained, and have a water table within 1-1.5 ft. from the surface for extended periods of time, typically one week or more. Alternately, soils may also be ponded for long durations during the growing season. Organic matter also influences the formation of redoximorphic features characteristic of wetlands. Redoximorphic features did not form in soils with less than 1.5% organics, while soils with 3% or greater were most effective in producing redox depletion in flood plots.

There was a distinct lack of information to be found in the literature documenting the use of non-hydric soils for wetland mitigation. This type of construction (specifically for mitigation purposes) was typically documented in engineering reports describing wetland mitigation designs and construction, and is not generally published in scientific journals. Such descriptions usually describe the soils used from an engineering view and consequently were of limited use to this study. However, the information contained in reports such as these pertaining to hydrological conditions for the study sites, proved quite valuable.

The second phase of the project entailed selecting at least five sites where wetland mitigation projects had either been completed or were underway utilizing non-hydric soils. Five such sites were located in three New England states. They included the Pine Road Wetland Mitigation Site in Brentwood, NH, the Bangor Hydroelectric Graham Lake Dam remediation wetland mitigation site in Ellsworth, ME; the Maine Department of Transportation wetland mitigation site at the old Maine Turnpike southbound Exit 6 in Scarborough, ME; the cloverleaf exit from I-691 to Route 10 in Cheshire, CT; and the Michelle Memorial Park wetland mitigation in Salem, NH. Each site was visited, and measurements were made of the hydrologic conditions. Three to four small diameter wells (SDW) were installed at each site to measure the groundwater levels, and to test for hydraulic conductivity. The installed wells, and any existing site wells, were tied together by a survey to facilitate creating a groundwater piezometric map. Test pits were dug in at least three locations at each site for the purpose of characterizing the soils according to color, redoximorphic features, and temperature. Soil samples were taken back to the laboratory to measure the organic content, evaluate the nutrients in the soil and measure the particle size distribution.

In addition to the field data, existing information on the site construction and source of the non-hydric soils was sought from either the site owner, or the engineering firms which did the design and supervised the construction of the mitigation sites. The selection included sites that were 1.5, 3, 4 and 10 years old. Site soils ranged from a grey silty fine sand to a brown till, with a significant silt and clay content. The hydrology of the sites varied from a site primarily fed by groundwater to one maintained by a combination of groundwater and surface water. The surface water created ponded conditions over a portion of the site. Three of the sites examined had ponded water over a portion of the site. Each site contained at least some sedge wetlands. Each site was deemed a successful mitigation project. Several sites, the Bangor Hydroelectric Graham Lake wetland mitigation site in particular, had a significant portion of volunteer vegetative wetland specifics in addition to limited plantings of woody shrubs and bushes.

The field data were analyzed for hydrologic and soil characteristics. Hydraulic conductivities ranged from 1×10^{-2}cm/s to 8×10^{-5} cm/s. The soils ranged from a sand which demonstrated distinct hydric conditions to the high chroma reddish brown mineral soils at the Connecticut site which served to mask some of the hydric indicators. Soils evaluated included sands, loamy sands, sandy loams, and silty clays. In every instance where long term hydrologic data were available, it appeared the water table came within one foot of the surface for a minimum of a one month period throughout the year. The study found that saturation alone was not sufficient to develop all of the many hydric soil Field Indicators. Depletion of oxygen was found to be an important condition for the full development of the Field Indicators. In the case of the Connecticut site, the water source was theorized as being too oxygenated to develop the gray colors indicative of redoximorphic features. Surficial soils from the Pine Road site did not qualify as hydric according to the Field Indicators, yet did meet the Hydric Soil Criteria, using an 'alpha', 'alpha prime', dipyridyl test.

The morphological index values were calculated for all sampled soils. The values demonstrated that there was a distinct statistical difference between the hydric and the non-hydric soils among those collected. Texture of the soil did not correlate to the morphological index, indicating that texture was not an important factor for the development of hydric characteristics. Two of the coarser hydric soils did not react with 'alpha', 'alpha prime' dipyridyl, presumably due to removal of the soluble reduced iron by percolating water. Age of the site did not significantly correlate with the morphological index. This indicated that the hydric characteristics formed relatively rapidly in the non-hydric mitigation soils, at least within the first two years. This was substantiated by a laboratory experiment performed to evaluate the effect of organic content of the soils.

Organic content was found to be strongly correlated to the morphological index of the soils. To confirm this finding, a laboratory experiment was performed taking soils from four of the sites, adding varying amounts of organic material, and placing them in saturated conditions to create hydric conditions. Four samples were tested from each of the four sites; one with no organic matter, one with 1.5% organic matter, one with 3% organic matter, and one with 3% plus sugar added as an additional nutrient. The analyses were intended to evaluate the time required for each soil to form hydric conditions based on the Field Indicators. The soils with the 3% organic matter added showed distinct signs of the potential to develop the soil color features associated with reduced iron. In 90 days, each of the soils moved in that direction. The added nutrients accelerated the color characteristic development.

The overriding requirement for the use of non-hydric soils for wetland mitigation is that the hydrological conditions must be appropriate. The hydroperiod and depth of groundwater fluctuations must be such that the surficial soil profile is saturated for at least 7 days of the growing season, and sufficient moisture is maintained throughout the growing season to sustain hydrophytic vegetation. The non-hydric mitigation soil should have at least 3% organic content to facilitate the formation of hydric characteristics. Within these requirements, almost any soil should become a hydric soil.

Guidelines were developed to match appropriate soils to the wetland type and the site hydrology. It was suggested that more permeable soils are better suited to endosaturated wetland areas (groundwater fed) while less permeable fine-grained soils are more suited for episaturated (surface water) fed systems. Nutrient additions may be required for initial planting of wetland vegetation, and should be tailored to the vegetation selected for the site.

REPORTS, PAPERS, AND PRESENTATIONS:

1. "Suitability of Non-Hydric Soils for the Mitigation of Wetlands," Brannaka, L.K. and Evans, C.V., February 28, 1997, NETCR5, Final Report.

PROJECT NUMBER: 95-3

PROJECT TITLE:
Implementation and Evaluation of Traffic Marking Recesses For Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes

PRINCIPAL INVESTIGATOR(S):
K. Wayne Lee. Stephen A. Cardi, II and Sean Corrigan
The University of Rhode Island and Cardi Corporation

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: 8/31/99

PROJECT OBJECTIVES:

If thermoplastic pavement striping is applied to a constructed recess in the pavement surface, snow plow blades would pass over without damaging either the marking or the pavement. This study will determine the best means of creating traffic marking recesses and the cost effectiveness of this method. To accomplish this task the URI research team will work with a contractor on an existing construction project to carry out a trial field installation of the traffic marking recesses. Construction specifications will be developed for this method by the URI research team with the assistance of the contractor.

After construction, the durability and retroreflectivity of the recessed markings will be monitored three times each year for two years. The monitoring and evaluation period will take place once prior to the winter maintenance season, once during the winter months and once after the winter maintenance season. The durability of the recessed markings will be evaluated by a subjective rating method, and the retroflectivity will be measured by a retroreflectomer. A narrative videotape of late night wet weather condition review of the test sections will also be produced by the URI research team. The final report will be submitted within 3 weeks of the final evaluation and will include pictures of each evaluated section, the late night wet-weather video, as well as comparisons of the recessed and non recessed areas' durability and retroreflectivity.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
On Thursday, December 5, 1996, three test sections of recessed (and non-recessed) thermoplastic traffic markings were successfully installed on I-95 Northbound by Cardi Corporation under the direction of the URI research team. The creation of the traffic marking recesses and the application of

thermoplastic traffic markings to the recesses were well-documented with photographs and video, taken by the URI research team. Detailed construction specifications for the creation of traffic marking recesses were developed from this documentation.

An interim report was prepared based on results of two evaluations, and sent to the NETC Coordinator for the technical committee's review. Due to the mild weather of 1997-98 Winter, the fifth field evaluation was not feasible. Upon the recommendation of the NETC Advisory Committee, an amended proposal was approved to extend the project end period to 8/31/99, and a new schedule for field performance evaluation has been set up as follows:

5th evaluation	dry night	June or July 1998
6th evaluation	wet night	November 1998
7th evaluation	dry day	Spring 1999

On July 2, 1998, the fifth (5th) evaluation was performed on dry night for the comparative purpose. The retroreflectivity measurements were taken by the Reto-Lux 1500 retroreflectometer. Two readings were taken at the first third and second third of each skip strip and then were averaged to represent the retroflectivity of the entire stripe. The durability of each stripe was also determined by utilizing the percentage-retained method.

A statistical analysis (t-test) of the data collected from the five durability and retroreflectivity evaluations of the three test sections was performed. The cost and cost effectiveness of recessing thermoplastic traffic markings was also determined. The cost effectiveness was determined through a 20 year life cycle cost analysis comparing recessed to the non-recessed thermoplastic markings.

REPORTS, PAPERS, AND PRESENTATIONS:

1. A PowerPoint presentation of the interim findings was given at the Rhode Island Transportation and Civil Engineering Forum held on October 21, 1998 at the Chester H. Kirk Center for Advanced Technology, hosted by the University of Rhode Island.

PROJECT NUMBER: 95-5

PROJECT TITLE:
Buried Joints in Short Span Bridges

PRINCIPAL INVESTIGATOR(S):
George Tsiatas and K. Wayne Lee, University of Rhode Island

STATUS: Continuing

INITIAL AGREEMENT DATE: 8/1/95

END DATE: Completion of Work

PROJECT OBJECTIVE:
The objective of project 95-5 is to determine the viability of buried joints in short span steel and concrete bridges in New England.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
An extensive study of various expansion joint systems used in the New England states was undertaken. Common types of joints used at present are: buried joints for movements up to 1.5-2 inches, strip seals for movements up to 4 inches, and finger or modular joints for movements greater than 4 inches. In the states of Vermont and Maine a modified strip seal joint and a modified compression seal joint, respectively, are used for movements up to 3-4 inches. Performance and cost information related to the above expansion joint systems was collected.

A parametric study of expected movements for various span lengths due to temperature changes was made. It is found that the 2 inch allowed movement of the joint material can accommodate a large number of existing highway bridges.

An analytical investigation of the following types of joint connections was undertaken for a two span (93 ft. and 84.5 ft.) structure with an expansion joint over the middle pier: no structural connection (asphalt plug), continuous concrete deck over the joint, steel lap plate connecting the top flanges of the girders, connection of the webs of the girders and full moment connection. The analysis was conducted using a detailed model of the bridge which allowed for the determination of the stress field in the vicinity of the expansion joint. Temperature effects were studied in order to evaluate expected movements and required clearances.

REPORTS, PAPERS AND PRESENTATIONS :

1. "State of the Art Study of Bridge Joint Systems in New England," Tsiatas, G. and Chandrasekaran, S. A paper submitted for presentation at the Annual Meeting of the Transportation Research Board, Washington, D.C., January 1997.

PROJECT NUMBER: 96-1

PROJECT TITLE:
Implementation of Superpave

PRINCIPAL INVESTIGATOR(S):
Jack E. Stephens & James Mahoney
CAPLab/Transportation Institute
University of Connecticut

STATUS: New

INITIAL AGREEMENT DATE: 9/1/97

END DATE: 8/31/99

PROJECT OBJECTIVE(S):
Assist states in implementation of Superpave.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Asphalt binder samples for the Binder Technician Workshop were distributed during the Fall of 1997. Binder samples were sent to the states which then carried out DSR and BBR tests under their interpretation of the provisional AASHTO testing protocols.

Project emphasis during 1998 has continued to be Superpave Binder technology. A binder technician workshop was conducted in January at the CAPLab for the New England states in cooperation with NECEPT. James Mahoney assisted NECEPT with a similar workshop at Penn State for NY, PA, NJ, DE, and MD held a few days later. The results of the fall 1997 Binder Technician Workshop Samples were presented and test data variations discussed in depth with the technicians in attendance at the workshops. As this was the first sizable testing program, NECEPT at several meetings found nationwide interest in the rather large variation found in results which was a surprise to many.

After the workshop, the 1998 Round Robin was distributed. The CAP Lab prepared samples aged in the pressure aging vessel for all participants. Results were received slowly as some labs were overwhelmed with construction season testing loads. Results are now being analyzed and a report in preparation. This round robin was again expanded beyond New England by NECEPT.

Under this project (96-1) the CAPLab then attempted to separate the large variation found in the fall 97 samples sent out for the binder technician workshop based on that due to the handling of the samples and that due to testing techniques. Toward this goal, the CAPLab prepared molded DSR samples ready for insertion in the test machine. These were shipped by over-night delivery with explicit instructions as to when to test. Some samples did not resist shipping stresses well and minor remolding was required. In spite of these difficulties, the average standard deviation of the Pre-molded samples tested at the designated time was about half as great as that of the first Round Robin.

As part of this project, the CAPLab has begun to collect binder testing data throughout the New England States. The CAPLab will try to match up tests results from different states on samples which came from the same supplier and lot. Sufficient matching to be useful will be difficult as some of the states did not record the supplier's lot number on their lab reports. If this does prove feasible, the CAPLab will develop a data-base from which comparisons can be made of the differences between testing agencies as well as sampling locations (terminal, truck or mix plant). With this information, it may be possible to determine where test result differences originate.

During the summer and fall, James Mahoney visited all six New England and New York State laboratories. The visits were scheduled so that he could observe DSR, BBR and Rotary Viscosity testing. After observing techniques, discussions were held of any questionable phases. Help was also given with machine difficulties.

The Technical Committee for this project met. Past and future activities were presented and discussed.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 96-2

PROJECT TITLE:
Optimizing GPS Use in Transportation Projects

PRINCIPAL INVESTIGATORS:
C. Roger Ferguson, University of Connecticut, and John E. Bean, Central Connecticut State University

STATUS: New

INITIAL AGREEMENT DATE: 7/1/97

END DATE: 6/30/99

PROJECT OBJECTIVES: Multiple objectives for each of the six project tasks are listed in the project proposal.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Met with representatives of the three primary GPS equipment vendors to discuss available equipment, equipment features, and equipment prices. Information obtained from these meetings will be used in matrix compilation for Task 2. Arranged for each of the vendors to exhibit their wares and answer questions about GPS equipment and technology at a combined meeting of all of the New England GPS users that will be coordinated as part of this project.

Completed preparation of a web site to disseminate information about this project. Delivery date for the hard drive upon which this will reside is past due at Central Connecticut State University. Site should be up and running by 12/31/98.

Completed draft reports of the summer 1997 individual meetings with each New England State DOT and distributed them to the DOTs for comment, correction, and additional information which was missed in the meeting minutes and we thought other meeting attendees might help us recall. Made calls to all of the DOTs to obtain responses when none were forthcoming after a month. Several responses were obtained after the calls, but one or two are still needed to finalize these reports. Recent communications indicate that these responses will not be forthcoming, so the reports will be completed by 12/31/98 without them.

Completed the draft composite report of the summer 1997 New England State DOT meetings. Completion of this report depends on the same responses mentioned in the above paragraph. 12/31/98 completion anticipated.

Ascertained that all of the states would like to have a New England DOT GPS users meeting in the Concord, NH area, and that most of them are willing to make a presentation about some aspect of their GPS use at the meeting. Initially, the meeting was to have been in Nov. 1998, but responses to the question about desire for the meeting and willingness to participate came only after a reminder telephone call, and not in time to organize the meeting for November. Respondents indicated they would like to have the meeting in Spring 1999.

Processed purchase order for real-time geodetic GPS base station at Central Connecticut State University (CCSU).

Attended two-day ESRI training class in MapObjects (funded by CCSU).

Worked on survey control portion of website using MApObjects Internet Map Service (MS).

Visited Pacific Northwest Geodetic Array (PANGA) to investigate operation of a large-scale continuously operating GPS network (airfare funded by CCSU). Report of visit posted to web site.

Continued work on Kinematic GPS studies.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 96-3

PROJECT TITLE:
Effectiveness of Fiber Reinforced Composites as Structural and Protective Coverings for Bridge Elements Exposed to Deicing-Salt Chlorides

PRINCIPAL INVESTIGATOR(S):
Perumalsamy Balaguru, Rutgers, The State University of New Jersey and K. Wayne Lee, University of Rhode Island

STATUS: New

INITIAL AGREEMENT DATE: 8/31/97

END DATE: 7/31/99

PROJECT OBJECTIVE(S):
The primary objective of the proposed research is to identify a cost effective composite system that will provide long-term performance under freeze-thaw, wet-dry, and deicing salt environments. The primary tasks are (i) selecting the promising candidates in terms of materials, combination of fibers and matrices, and application techniques, and (ii) evaluation of the selected materials and systems for long-term performance.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
The major accomplishments are: (i) preparation of State-of-the-Art Report and review by the technical committee, (ii) preliminary evaluation of inorganic matrix, (iii) durability study in progress and (iv) field applications.

At the end of the literature search, a report was prepared, and the technical committee met in March 1998. It was decided to evaluate organic matric inorganic matrix, and hybrid matrix reinforced with discrete and continuous fibers. As the research progressed, we are focusing more on the inorganic matrix because of its compatibility with concrete. An extensive study was conducted in California on the behavior of organic matrix reinforced with glass and carbon fabrics. The results of this study will be used for the final report.

For the field applications, two structures were chosen in Rhode Island. The first one was a New Jersey divider, which was coated with three formulations. These formulations contained different amounts of fillers to improve the durability. We learned that special equipment is needed for the application of thicker coatings. One of the formulations is performing well, even though, it was applied at a temperature lower than recommended temperature and minimal surface preparation.

For the second structure, three formulations with paint consistency were applied to curb-wall and an abutment, Fig. 1. These were applied with brushes and they were also successfully applied using a sprayer at Rutgers. The mixing and spraying equipment are shown in Fig. 2. All the three formulations are performing well.

It is expected that more structures will be coated with composites reinforced with fibers in the future.

REPORTS, PAPERS AND PRESENTATIONS:

1. "Inorganic Matrices for Composites," NSF Workshop on Composites, Hanover, NH, March 15, 1998.
2. "Behavior of Geopolymer Reinforced with Various Types of Fabrics," SAMPE 1998, Anaheim, CA, May 1998.
3. "Use of Ferrocement Theory for Analysis of High Strength Composites," Ferrocement VI, Ann Arbor, MI, June 1998.
4. "Advances in Composites," National University of Singapore, July 19, 1998.

PROJECT NUMBER: 97-1

PROJECT TITLE: A Portable Method to Determine Chloride Concentration on Roadway Pavements - Phase I

PRINCIPAL INVESTIGATORS (S):
Nikolaos P. Nikolaidas, University of Connecticut
Norman W. Garrick, University of Connecticut

STATUS: New

INITIAL AGREEMENT DATE: 9/1/98

END DATE: 8/31/99

PROJECT OBJECTIVES:
To develop a technology, to be used in conjunction with a management framework, that would result in the application of an optimum quantity of road deicer thereby reducing the cost and minimizing the undesirable water quality effects of chloride, while, at the same time, preserving highway safety.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Agreement executed.

REPORTS, PAPERS, AND PRESENTATIONS: None

PROJECT NUMBER: 97-2

PROJECT TITLE: Performance Evaluation and Economic Analysis of Combinations of Durability Enhancing Admixtures (Mineral and Chemical) in Structural Concrete for the Northeast U.S.A.

PRINCIPAL INVESTIGATOR(S):
James M. LaFave, Ph.D., P.E., University of Massachusetts, Amherst

STATUS: NEW

INITIAL AGREEMENT DATE: 8/30/98

END DATE: 8/30/01

PROJECT OBJECTIVES:
To evaluate the performance of chemical and mineral durability enhancing admixtures in structural reinforced concrete mixes typical of those specified by State Transportation Agencies in New England.

To develop guidelines, for the New England State Transportation Agencies, on the specification and usage of chemical and mineral admixtures that will address their expected long-term durability enhancement and their overall life cycle economic impacts.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
Agreement executed.

REPORTS, PAPERS, AND PRESENTATIONS: None

PROJECT NUMBER: 97-3

PROJECT TITLE:
Determining Properties, Standards and Performance of Wood Waste Compost as an Erosion Control Mulch and as a Filter Berm

PRINCIPAL INVESTIGATOR(S):
Richard P. Long and Kenneth R. Demars
University of Connecticut

STATUS: New

INITIAL AGREEMENT DATE: 8/1/98

END DATE: 7/31/00

PROJECT OBJECTIVE(S):
The objective of this proposed study is to perform laboratory and field testing of the physical and chemical properties and behavior of wood waste compost for use in erosion control on construction projects. The two applications of interest are the use of compost as an erosion control mulch on slopes and as an erosion control filter berm. Particular goals include 1) determine the minimum effective thickness of wood waste compost for protecting slopes from erosion during rain events, 2) evaluate the limits of stability and shear strength for wood waste compost, 3) a comparison of alternate methods of containing eroded soil including hay bales, geotextiles, and filter berms containing composted materials, 4) the development of criteria to predict the field behavior of wood waste compost for various uses, and 5) recommendation of product standards.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:
A project kickoff meeting was held in Portland Maine during mid-September which was attended by the PIs, representatives of ConnDOT, Maine DOT and NHDOT plus two wood waste compost producers from Maine. Several of the attendees visited a compost producer in Sabbath Day, Maine. Some wood waste compost and mulch samples were obtained for laboratory testing.

A supply of wood waste compost that is produced in Connecticut was identified. Apparently ConnDOT produces compost from stump grindings once per year and these materials may be used on this project.

A potential field test site was identified and visited. Being at the junction of Routes 44 and 32 in Willington, CT, it is convenient to UConn, which will facilitate data collection. There appears to be adequate space for 14 cells, including two control cells, and a 2 to 1 slope. The soil appears erodible. The test cells have been drawn up and forwarded to ConnDOT personnel. These are being reviewed and cost estimate made.

Laboratory analysis for physical and chemical properties of the wood waste are underway. An early spring 1999 installation is planned.

REPORTS, PAPERS AND PRESENTATIONS: None

PROJECT NUMBER: 97-4

PROJECT TITLE:
Early Distress of Open-Graded Friction Course (OGFC)

PRINCIPAL INVESTIGATORS:
Jack E. Stephens, James M. Mahoney and Charles E. Dougan
CAP Lab/Transportation Institute, University of Connecticut

STATUS: New

START DATE: June 1, 1998

END DATE: December 31, 1999

PROJECT OBJECTIVES:

1. Determine the type and extent of failures in OGFC being experienced in New England.

2. Compare failures in OGFC with sections that are performing well.

3. Develop specification requirements for OGFC based on the state-of-the-art.

4. Prepare recommended maintenance and rehabilitation practices and specifications for use on failed sections of OGFC.

PROGRESS/ACCOMPLISHMENTS THROUGH DECEMBER 31, 1998:

1. Completed TRIS search on OGFC.

2. Hosted project advisory panel meeting 8/19/98 in Methuen MA. The panel approved various field evaluation methods which included friction, surface texture, air permeability and tabulation of crack counts and other types of distresses in both good and bad pavement sections. Each state representative designated the sites to be field evaluated.

3. Completed field surveys of poor and good sections designated by Vermont, Massachusetts and Rhode Island and poor designated by Connecticut. Each state provided traffic control and coring. Connecticut performed friction tests in all states.

4. Field data tabulated and initial analysis started.

5. Obtained available mix design and construction data on all field test sites.

6. Continued to seek additional data and information on the state-of-the-art. Georgia DOT has been helpful in this effort.

REPORTS, PAPERS AND PRESENTATIONS : None

D. FINANCIAL STATUS
Active Projects

Table 1: Financial Status Of Projects Active During 1998 (As Of 12/31/98)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
Tire Chips As Lightweight Backfill:PHASE II: Full-Scale Testing *P.I.: Dana Humphrey, University of Maine, Orono*	111,000.00	111,000.00	0.00 Project Closed 7/15/98
Bridge Rail Crash Test, PHASE II: Sidewalk Mounted Rail *P.I.: Eric C. Lohrey, Connecticut DOT*	134,127.00	134,127.00	0.00
94-1: Structural Analysis of New England Subbase Materials And Structures *P.I.: K. Wayne Lee, University of Rhode Island*	111,497.00	108,111.37	3,385.63
94-2: Nondestructive Testing Of Reinforced Concrete Bridges Using Radar Imaging *P.I.: Dryver Huston, University of Vermont*	224,902.00	193,329.04	31,572.96
94-3: Procedures for the Evaluation of Sheet Membrane Waterproofing *P.I.: Charles J. Korhonen, Cold Regions Research and Engineering Laboratory, Corps of Engineers*	67,000.00	22,333.33	44,666.67
94-4: Durability of Concrete Crack Repair Systems *P.I.: George Tsiatas University of Rhode Island*	84,850.00	57,927.16	26,922.84

Table 1: Financial Status Of Projects Active During 1998
(As Of 12/31/98) (cont'd)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
95-1: Use of Tire Chips/Soil Mixtures to Limit Frost Heave And Pavement Damage of Paved Roads *P.I.: Dana Humphrey, University of Maine, Orono*	75,000.00	73,120.10	1,879.90
95-3: Implementation and Evaluation of Traffic Marking Recesses For Application Of Thermoplastic Pavement Markings On Modified Open Graded Mixes *P.I.s: K. Wayne Lee University of Rhode Island*	132,314.00	97,005.29	35,308.71
95-5: Buried Joints In Short Span Bridges *P.I.s: George Tsiatas and K. Wayne Lee, University of Rhode Island*	64,910.00	61,705.61	3,204.39
95-6: Guidelines for Ride Quality Acceptance of Pavements *P.I.s: John Collura, University of Massachusetts, Amherst; Tahar El Korchi, and N. Wittels, Worcester Polytechnic Institute, Worcester*	106,124.00	106,124.00	0.00
96-1: SUPERPAVE™ Implementation *P.I.: Jack Stephens, University of Connecticut*	74,978.00	12,942.16	62,035.84
96-2: Optimizing GPS Use in Transportation Projects *P.I.: C. Roger Ferguson, University of Connecticut*	120,000.00	31,300.80	88,699.20

Table 1: Financial Status Of Projects Active During 1998 (As Of 12/31/98) (cont'd)

PROJECT	APPROVED BUDGET	INVOICED TO DATE	PROJECT BALANCE
96-3: Effectiveness of Fiber Reinforced Composites As Structural and Protective Coverings for Bridge Elements Exposed to Deicing-Salt Chlorides *P.I.s: Perumalsamy N. Balaguru, Rutgers University; K. Wayne Lee, University of Rhode Island*	135,000.00	45,274.94	89,725.06
97-1: A Portable Method to Determine Chloride Concentration on Roadway Pavements *P.I.s: N.W. Garrick, N.P. Nikolaidis, University of Connecticut*	204,664.00	21.60	204,642.40
97-3: Determining Properties, Standards and Performance of Wood Waste Compost as an Erosion Control Mulch and as a Filter Berm *P.I.s: K. Demars, R.P. Long, University of Connecticut*	54,649.00	0.00	54,649.00
97-4: Early Distress of Open-Graded Friction Course (OGFC) *P.I.s: J. Stephens, J. Mahoney, C. Dougan, University of Connecticut*	79,865.00	12,616.04	67,248.96

Table 2: NETC Fund Balance

(As Of 12/31, 1998)

ITEM	ALLOCATION	ENCUMBRANCE/ EXPENDITURE	CUMULATIVE BALANCE
Unexpended Balance of NETC funds from AASHTO			
as of 6/5/95 (Per AASHTO memo 12/4/95)			132777.07
Member Allocations 1994 = 6 X $75,000	450000		582777.07
Coordination/Administration of NETC: Calendar Year 1995		58508.02	524269.05
Continued Projects:			
- Construction Costs of New England Bridges-Phase II		39500	484769.05
- Tire Chips as Lightweight Backfill-Phase II: Full-Scale Testing			
(Supplemental Funding)		16000	468769.05
- Bridge Rail Crash Test - Phase II:Sidewalk-Mounted Rail		134127	334642.05
- New England Vehicle Classification and Truck Weight Program		6752.57	327889.48
Member Allocations 1995 = 7 X $75,000	525000		852889.48
"95" Project Series:			
95-1: Use of Tire Chips/Soil Mixtures to Limit Pavement Damage			
of Paved Roads		75000	777889.48
95-2: Suitability of Non-Hydric Soils for Wetland Mitigation		39867.7	738021.78
95-3: Implementation and Evaluation of Traffic Marking Recesses			
for Application of Thermoplastic Pavement Markings			
on Modified Open Graded Mixes		132313	605708.78
95-5: Buried Joints in Short Span Bridges		64910	540798.78
95-6: Guidelines for Ride Quality Acceptance of Pavements		106124	434674.78
"94" Project Series:			
94-1: Structural Analysis of New England Subbase Materials and			
Structures		111497	323177.78
94-2: Nondestructive Testing of Reinforced Concrete Bridges			
Using Radar Imaging Techniques		224902	98275.78
Member Allocations 1996 = 6 X $75,000	450000		548275.78
Coordination/Administration of NETC: Calendar Year 1996		69123.85	479151.93
Member Allocations 1997 = 6 X $75,000	450000		929151.93
Coordination/Administration of NETC: Calendar Year 1997		82494	846657.93
"94" Project Series:			
94-3: Procedures for The Evaluation of Sheet Membrane Waterproofing		67000	779657.93
94-4: Durability of Concrete Crack repair Systems (Proposal)		84850	694807.93
"96" Project Series:			
96-1: SUPERPAVE Implementation		74978	619829.93
96-2: Optimizing GPS Use in Transportation Projects		120000	499829.93
96-3: Effectiveness of Fiber Reinforced Composites as Protective			
Coverings for Bridge Elements, etc.		135000	364829.93
Technology Transfer (per Dec. 2, 1997 Adv. Committee Mtg.) for 1998		10000	354829.93
Coordination/Administration of NETC: Calendar Year 1998		73021	281808.93
Member Allocations 1998 = 6 X $75,000	450000		731808.93
"97" Project Series:			
97-1: A Portable Method for Determining Chloride			
Concentration on Roadway Pavements		204664	527144.93
97-2: Performance Evaluation & Economic Analysis			
of Durability Enhancing Admixtures, etc.		118473	408671.93
97-3: Determining Properties, Standards & Performance			
of Wood Waste Compost, etc.		54649	354022.93
97-4: Early Distress of Open-Graded Friction Course		79865	274157.93

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NETC Fund Balance

(As Of 12/3 1, 1998)

(Continued)

ITEM	ALLOCATION	ENCUMBRANCE/ EXPENDITURE	CUMULATIVE BALANCE
Travel for Tech. Comm. for 1998 (per Aug. 98 tel. poll)		5000	
Member Allocations 1999 = 6 X $75,000	450000		719157.93
Coordination/Administration of NETC: Calendar Year 1999		98066	621091.93
"98/99" Project Series (Problem Statement Cost Estimates)		540000	81091.93
Note: Member allocations are obligated between October 1 and December 31 of the previous year.			

E. NETC REPORTS, PAPERS AND PRESENTATIONS

PROJECT NUMBER	TITLE
N/A	**REPORTS, PAPERS AND PRESENTATIONS 1988-1994:**

"Agreement to Implement a Common Set of Procedures for Issuing Permits for Nondivisible Oversize and Overweight Trucks Engaged in Interstate Travel," The New England Transportation Consortium, October, 1988.

"The New England Transportation Consortium, Round One Activities," Humphrey, T.F., and Maser, K.R., MIT, December 1988.

"The Development of a Common Regional System for Issuing Permits for Oversize and Overweight Trucks Engaged in Interstate Travel," Humphrey, T.F., May 1986.

"New Technology for Bridge Deck Assessment - Phase I Final Report," Vols. I and II, Maser, Kenneth R., MIT Center for Transportation Studies, October 1989.

"Bridge Rail Design and Crash Worthiness - Final Report," Elgaaly, M., Dagher, H., and Kulendran, S., University of Maine, May 1989.

"New England Transportation Consortium, Operational Procedures," Humphrey, T.F., November 1991.

"Handbook for Use by the Trucking Industry to Implement The NETC Common Truck Permit Procedures for Certain Nondivisible Oversize/Overweight Vehicles Traveling on State Highways." MIT Center for Transportation Studies, January 1989.

"Wetlands: Problem & Issues," Shuldiner, P.W., University of Massachussetts, August 1990.

"Development of a Uniform Truck Management System, Vols. I and II, Lee, K.W., and McEwen, E.E., University of Rhode Island. July 1990.

"New Technology for Bridge Deck Assessment - Phase II Final Report," MIT, May 1990.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
N/A	**REPORTS, PAPERS AND PRESENTATIONS 1988-1994 (cont'd):**

"A Study of STAA Truck Safety In New England - Phases I & II," MIT, November 1991.

"Rail Service In New England," Martland, C.P. Little, and Alvaro, A.E., MIT Center for Transportation Studies, April 1992.

"CMA Degradation and Trace Metals in Roadside Soil," Ostendorf, D.W., Palaia, T.A., and Zutell, C.A., University of Massachusetts, March 1993.

"Tire Chips as Lightweight Backfill for Retaining Walls - Phase I." Humphrey, D., Sandford, T.C., Cribbs, M.M., Gharegrat, H.G., and Manion, W.P., University of Maine, August 1992.

"Cooperative Regional Transportation Research Programs Underway in New England, Humphrey, T.F., and Sussman, J.M., International Congress on Technology and Technology Exchange, June 1989.

"Uniformity Efforts in Oversize/Overweight Permits," Humphrey, T.F., NCHRP Synthesis, No. 143, Transportation Research Board, 1988.

"Implementation of a Uniform Truck Permit System by the New England Transportation Consortium," Humphrey, T.F., AASHTO 1987 Annual Meeting Proceedings, pp. 84-90, 1987.

"Advantages of Oversize/Overweight Truck Permit Uniformity, AASHTO 1990 Annual meeting Proceedings, pp. 83-85, 1990.

"Crash Worthiness of Bridge Rails," Dagher, H., Elgaaly, M., and Kulendran, S., Proceedings, Fourth Rail Bridge Centenary Conference, Heriot-Watt University, Edinburgh, Scotland, August 1990.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd):

PROJECT NUMBER	TITLE
N/A	**REPORTS, PAPERS AND PRESENTATIONS 1988-1994 (cont'd):**
	"Principles of Radar and Thermography for Bridge Deck Assessment," Maser, K.R., and Roddis, W.M.K., ASCE Journal of Transportation Engineering, Vol. 116, No. 5, Sept./Oct. 1990.
	Martland, C.P. Little, and Alvaro, A.E., "Regional Rail Planning In New England," MIT, August 1993. (Accepted for publication 1994)
	"CMA Degradation in Roadside Soil: Acetate Microcosms", Ostendorf, D.W., Pollock, S.J., De Cheke, M.E., and Palaia, T.A., Transportation Research Record, No. 1366, pp. 41-43, 1992.
	"Aerobic Degradation of CMA in Roadside Soils: Field Simulations from Soil Microcosms," Ostendorf, D.W., Pollock, S.J., De Cheke, M.E., and Palaia, T.A, Journal of Environmental Quality, Vol. 22, pp. 229-304, 1993.
	"Shear Strength and Compressibility of Tire Chips for Use as Retaining Wall Backfill," Humphrey, D.N., Sandford, T.C., Cribbs, M.M., and Manion, W.P., *Transportation Research Record No. 1422*, pp. 29-35, Transportation Research Board, National Research Council Washington, D.C., 1993.
	"Tire Chips as Lightweight Subgrade Fill and Retaining Wall Backfill," Humphrey, D.N., and Sandford, T.C., *Proceedings of the Symposium on Recovery and Effective Reuse of Discarded Materials and By-Products for Construction of Highway Facilities*, pp. 5-87 to 5-99, Federal Highway Administration, Washington, D.C., 1993.
N/A	**POLICIES AND PROCEDURES:**
	"Policies and Procedures, New England Transportation Consortium," July 1995.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
N/A	**ANNUAL REPORTS:**
	"ANNUAL REPORT For Calendar Year 1995," March 1996, NETCR3
	"ANNUAL REPORT For Calendar Year 1996," January 1997, NETCR4
	"ANNUAL REPORT For Calendar Year 1997," January 1998, NETCR9
	"ANNUAL REPORT For Calendar Year 1998, January 1999, NETCR10
NONE	**CONSTRUCTION COSTS OF NEW ENGLAND BRIDGES:**
	Reports:
	"Construction Costs of New England Bridges," Final Report, Alexander, J.A., Dagher, H. and James, S., November 1996, NETCR1.
	Papers and Presentations:
	"Construction Costs of New England Bridges," Alexander, J., Dagher, H. and James, S. Presented at the Annual Maine Transportation Conference, December 7, 1995.
NONE	**TIRE CHIPS AS LIGHTWEIGHT BACKFILL FOR RETAINING WALLS, PHASE II: FULL-SCALE TESTING:**
	Reports: None

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
NONE	**TIRE CHIPS AS LIGHTWEIGHT BACKFILL FOR RETAINING WALLS, PHASE II: FULL-SCALE TESTING (cont'd):**

Papers and Presentations:

"Tire Shreds as Lightweight Retaining Wall Backfill-Active Conditions," Humphrey, D. Submitted for publication in the ASCE Journal of Geotechnical and Geoenvironmental Engineering.

"Civil Engineering Uses for Tire Chips," Humphrey D. N. A six-hour short course presented to the Nebraska Department of Environmental Quality, the Maine Dept. of Transportation, the Texas Engineering Extension Service, the Manitoba Tire Stewardship Board, the Alberta Tire Recycling Management Board, and the Arkansas Department of Pollution Control and Ecology.

"Tire Chips as Lightweight Subgrade and Retaining Wall Backfill," by Humphrey, D.N. and Sandford, T.C. Symposium on Recovery and Effective Reuse of Discarded Materials and By-Products for Construction of Highway Facilities, FHWA, Denver, Colorado, October 19-22, 1993.

"Use of Tire Chips as Subgrade Insulation and as Lightweight Fill for Highway Construction," Humphrey, D. N. Presented at the 18th Annual Meeting of the Asphalt Recycling and Reclaiming Association, Pompano Beach, Florida, February 23-26, 1994.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
NONE	**TIRE CHIPS AS LIGHTWEIGHT BACKFILL FOR RETAINING WALLS, PHASE II: FULL-SCALE TESTING (cont'd):**

Papers and Presentations (cont'd):

"Use of Tire Chips in Highway Construction," Humphrey, D. N. Presented to the New England Environmental Expo, Boston, Massachusetts, May 9, 1995.

"Use of Tire Chips in Highway Construction," Humphrey, D. N. Presented to the AASHTO Region 1 RAC Meeting, Portland, Maine, May 23, 1995.

"Tire Chips for Highway Construction," Humphrey, D. N. Presented to the Northeast Recycling Council in Sturbridge, Massachusetts on December 8, 1995.

"Tire Chips: A New Road Building Geomaterial," Humphrey, D. N. Presented at the Conference on Waste and Recycled Materials in the Transportation Infrastructure, held in conjunction with the 75th Annual Meeting of the Transportation Research Board, January 7, 1996.

"Use of Tire Chips in Civil Engineering." Presented at the 76th Annual Meeting of the Rubber Association of Canada, March 7, 1996.

"Civil Engineering Uses for Scrap Tires," Humphrey, D. Presented at Scrap Tire '96 held in Chicago, Illinois on August 16, 1996.

"Full Scale Field Trials of Tire Chips as Lightweight Retaining Wall Backfill-At Rest Conditions," Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., *Transportation Research Board No. 1619*, Transportation Research Board, Washington, D.C., p. 64-71, 1998.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE

NONE — **TIRE CHIPS AS LIGHTWEIGHT BACKFILL FOR RETAINING WALLS, PHASE II: FULL-SCALE TESTING (cont'd)**

Papers and Presentations: (cont'd)

Tweedie, J.J., Humphrey, D.N., and Sandford, T.C., "Tire Shreds as Retaining Wall Backfill, Active Conditions," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 124, No. 11, Nov., pp. 1061-1070, 1998.

A Short Course on "Highway Applications of Tire Shreds" presented in each of the six New England states.

NONE — **NEW ENGLAND VEHICLE CLASSIFICATION AND TRUCK WEIGHT PROGRAM, PHASE I**

Reports:

"New England Vehicle Classification and Truck Weight Program, Technical Report No. 1: Toward the Development of a Vehicle Classification Program for New England," Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T., and Shuldiner, P., April 1996.

"New England Vehicle Classification and Truck Weight Program, Technical Report No. 2: Toward the Development of a Truck Weight Program for New England," Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T., and Shuldiner, P., April 1996.

"New England Vehicle Classification and Truck Weight Program, Technical Report No. 3: Supplemental Analysis of Truck Weight Data Collection at SHRP Continuous Count Stations," Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T., and Shuldiner, P., April 1996.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
	Reports (cont'd)
	"New England Vehicle Classification and Truck Weight Program, Phase I," Final Report, Collura, J., Chan, D., Evans, E., Kelly, S., Hosmer, T. and Shuldiner, P., April 1996, NETCR2.
	Papers and Presentations:
	"An Analysis of Vehicle Class and Truck Weight Patterns in New England," Collura, J. and Orloski, F. Presented at the 1994 National Traffic Data Acquisition Conference, Rocky Hill, Connecticut, September 18-22, 1994.
	"New England Vehicle Classification and Truck Weight Program," Collura, J. and Orloski, F. Presented to the Transportation Research Board's Highway Traffic Monitoring Committee, Annual Meeting of the Transportation Research Board, Washington, D.C., January 1995.
NONE	**BRIDGE RAIL CRASH TEST, PHASE II: SIDEWALK-MOUNTED RAIL**
	Reports:
	"NETC 2-Bar Curb-Mounted Bridge Rail Design - Plans and Specifications." Revised January 1997. "NETC 4-Bar Sidewalk-Mounted Bridge Rail Design - Plans and Specifications." January 1997.

PROJECT NUMBER	TITLE
NONE	**BRIDGE RAIL CRASH TEST, PHASE II: SIDEWALK-MOUNTED RAIL (cont'd)**

Reports (cont'd):

"Crash Testing and Evaluation of the NETC 2-Bar Curb-Mounted Bridge Rail," Mak, K.K., and Menges, W.L., February 1998, NETCR10.

94-1	**STRUCTURAL ANALYSIS OF NEW ENGLAND SUBBASE MATERIALS AND STRUCTURES (cont'd)**

Reports: None

Papers and Presentations:

"Structural Analysis of New England Subbase Materials and Structures," Davis, J. Presented at the Rhode Island Transportation and Civil Engineering Forum, Kingston, Rhode Island, October 23, 1996.

"Structural Analysis of New England Subbase Materials and Structures." Presented at the Northeast Graduate Student Symposium on Applied Mechanics, University of Rhode Island, April 26, 1997.

"Structural Analysis of New England Subbase Materials and Structures." Presented at the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 15, 1997.

"Structural Analysis of New England Subbase Materials and Structures," Davis, J., Huston, M., and Lee, K.W. Presented at the 1998 Annual Transportation Research Board Meeting.

"Structural Properties of New England Subbase Materials of Flexible Pavements." Presented at the 5th International Conference on the Bearing Capacity of Roads and Airfields on July 9, 1998.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE

94-1 **STRUCTURAL ANALYSIS OF NEW ENGLAND SUBBASE MATERIALS AND STRUCTURES (cont'd)**

Papers and Presentations (cont'd):

Results of resilient modulus test in accordance with the AASHTO TP-46 procedure were presented at the 11th Rhode Island Transportation and Civil Engineering Forum on 10/21/98.

94-2 **NONDESTRUCTIVE TESTING OF REINFORCED CONCRETE BRIDGES USING RADAR IMAGING TECHNIQUES**

Reports: None

Papers and Presentations:

"Bridge Deck Structural Monitoring Techniques," Huston, D. Presented at the New England State Materials Engineers Association Conference, Burlington, Vermont, October 9, 1996.

"Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Maser, K., Weedon, W., Fuhr, P.L., and Adam, C. in Structural Health Monitoring, Chang F., Editor, Technomic Publishing, pp. 91-109 Proceedings of the International Workshop on Structural Health Monitoring, Stanford, California, September 1997.

"Ground Penetrating Radar for Nondestructive Evaluation of Concrete Bridge Decks," Adam, C.S., Huston, D.R., Fuhr, P.L., Maser, K.R., and Weedon, W.H. Submitted to the American Concrete Institute student paper competition and American Concrete Institute Materials Journal, September 1997.

"Ground Penetrating Radar for Nondestructive Evaluation of Concrete Bridge Decks," M.S. Thesis in Mechanical Engineering, Adam, C., University of Vermont, October 1997.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE

94-2 **NONDESTRUCTIVE TESTING OF REINFORCED CONCRETE BRIDGES USING RADAR IMAGING TECHNIQUES (cont'd)**

Papers and Presentations (cont'd):

"GIMA Ground Penetrating Radar System for Infrastructure Health Monitoring," Huston, D.R., Hu, J.Q., Maser, K., Weedon, W., and Adam, C. Submitted to Journal of Applied Geophysics, October 1998.

"Ground Penetrating Radar for Concrete Bridge Health Monitoring Application," Huston, D.R., Hu, J.Q., Maser, K., Weedon, W., and Adam, C. Submitted for presentation at the SPIE Conference on Nondestructive Evaluation of Aging Infrastructure and Manufacturing, Newport Beach, CA, March 1999.

"GIMA Antenna Design for Ground Penetrating Radar in Concrete NDE Application," Hu, J.Q., Huston, D., and Fuhr, P. Submitted for presentation at the SPIE Conference on Nondestructive Evaluation of Aging Infrastructure and Manufacturing, Newport Beach, CA, March 1999.

"Bridge Deck Evaluation with Ground Penetrating Radar," Huston, D., Maser, K., Hu, J.Q., Weedon, W., and Adam, C. "Proceedings GPR '98 7th International Conference on Ground-Penetrating Radar, The University of Kansas, Lawrence, KS, May 27-30, 1998.

94-4 **DURABILITY OF CONCRETE CRACK REPAIR SYSTEMS**

Reports: None

Papers and Presentations:

"Durability of Concrete Crack Repair, Projects," Robinson, J. Presented at the University of Rhode Island Graduate Seminar Series, Kingston, RI, November 19, 1997.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE

95-1 **USE OF TIRE CHIPS/SOIL MIXTURES TO LIMIT FROST HEAVE AND PAVEMENT DAMAGE OF PAVED ROADS**

Reports: None

Papers and Presentations:

"Laboratory and Field Measurement of the Thermal Conductivity of Tire Chips for Use as Subgrade Insulation," Humphrey, D., Chen, L. H. and Eaton, R. A paper submitted to the Transportation Research Board for presentation at the session on "Properties of Unconventional Aggregates" at the Annual Meeting of the Transportation Research Board, Washington, D.C., January 1997.

An abstract based on the field work for the project was submitted for possible presentation at the 10th International Conference on Cold Regions Engineering to be held in August, 1999.

"Highway Applications of Tire Shreds,", Humphrey, D., a series of 7-hour short courses sponsored by NETC.

95-2 **SUITABILITY OF NON-HYDRIC SOILS FOR WETLAND MITIGATION**

Reports:

"Suitability of Non-Hydric Soils for Wetland Mitigation," Final Report, Brannaka, L.K. and Evans, C.V., February 28, 1997, NETCR5.

Papers and Presentations: None

95-3 **IMPLEMENTATION AND EVALUATION OF TRAFFIC MARKING RECESSES FOR APPLICATION OF THERMO-PLASTIC PAVEMENT MARKINGS ON MODIFIED OPEN GRADED MIXES**

Reports: None

PROJECT NUMBER | TITLE

95-3 **IMPLEMENTATION AND EVALUATION OF TRAFFIC MARKING RECESSES FOR APPLICATION OF THERMO-PLASTIC PAVEMENT MARKINGS ON MODIFIED OPEN GRADED MIXES (cont'd)**

Papers and Presentations:

"Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open Graded Mixes," Lee, K.W. Presented at the Rhode Island Transportation and Civil Engineering Forum, Kingston, Rhode Island, October 23, 1996.

"Implementation and Evaluation of Traffic Marking Recesses for Application of Thermoplastic Pavement Markings on Modified Open- Graded Mixes." Presented at the Rhode Island Transportation and Civil Engineering Forum, University of Rhode Island, October 15, 1997.

A PowerPoint presentation of the interim findings was given at the Rhode Island Transportation and Civil Engineering Forum held on October 21, 1998 at the Chester H. Kirk Center for Advanced Technology, hosted by the University of Rhode Island.

95-5 **BURIED JOINTS IN SHORT SPAN BRIDGES**

Reports: None

Papers and Presentations:

"State of the Art Study of Bridge Joint Systems in New England," Tsiatas, G. and Chandrasekaran, S. Submitted for presentation at the Annual Meeting of the Transportation Research Board, Washington, D.C., January 1997.

E. NETC REPORTS, PAPERS AND PRESENTATIONS (cont'd)

PROJECT NUMBER	TITLE
95-6	**GUIDELINES FOR RIDE QUALITY ACCEPTANCE OF PAVEMENTS**

Reports:

"Guidelines for Ride Quality Acceptance of Pavements," Final Report, Collura, J., El-Korchi, T., Black K., Chase, M. and Li, J., April 1997, NETCR 6.

Papers and Presentations: None

96-3	**EFFECTIVENESS OF FIBER REINFORCED COMPOSITES AS STRUCTURAL AND PROTECTIVE COVERINGS FOR BRIDGE ELEMENTS EXPOSED TO DEICING SALT CHLORIDES**

Reports: None

Papers and Presentations:

"Inorganic Matrices for Composites," NSF Workshop on Composites, Hanover, March 15, 1998.

"Behavior of Geopolymer Reinforced with Various Types of Fabrics," SAMPE 1998, Anaheim, CA, May 1998.

"Use of Ferrocement Theory for Analysis of High Strength Composites," Ferrocement VI, Ann Arbor, MI, June 1998.

"Advances in Composites," National University of Singapore, July 19, 1998.